Effect of integrated nutrient management on growth ~~parameters, yield components~~ and yield of wheat (*Triticum aestivum* L.) under central plain zone of Uttar Pradesh

Abstract

Field experiments were conducted to ~~studies~~ study theeffect ofintegrated nutrient management on growth parameters, yield components and yield of wheat during rabi season of 2020-21 and 2021-22 at students instructional farm, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur. The experiment consisted of 10 treatments combinationsin randomized block design with three replications consisted of different combination of inorganic fertilizer, organic manure and biofertilizer. Wheat variety HD-2967 was grown with the recommended agronomic practices. On the basis of results emanated from investigation it ~~can be concluded~~was found that among the growth parameters maximum plant height at maturity ~~is~~ was109.25 cm and 110.12, maximum number of effective tillers is 352.67 and355.72and maximum spike lengthis 13.55cm and 13.79 cm are associated with the treatment T_{10} [100%NPK+FYM+S_{30}+Zn_5+*Azotobacter*+ PSB] during the both years of experimentation. Similarly, among the yield components and productivity parameters maximum values in relation to number of spikelet ear^{-1}, grain ear^{-1}, 1000 grain wt. (gm), grain yield (q ha^{-1}) andstraw yield (q ha^{-1}) were found in the treatment T_{10} [100%NPK+FYM+S_{30}+Zn_5+*Azotobacter*+ PSB].

Key Words:*Azotobacter*, FYM, Phosphorous, PSB, Wheat and Yield.

Introduction

Wheat being an energy rich winter cereal contributes around 35% to the food grain basket of the country. Globally wheat (*Triticum aestivum* L.) is grown in 124 countries and occupied an area of about 215 million hectares with a production of 734.50 mt. of grain during 2019-20 **(Anonymous, 2020)**. In India the area under wheat increased since the start of green revolution in 1967 and the production and productivity also increased. The area under wheat increased from 12.8 mha. In 1966-67 to 31.45 mha. in 2019-20. In this period production has also increased from 11.4 to 107.59 mt. and the productivity was increased from 887 to 3421 kg ha^{-1}**(Anonymous, 2020).** Wheat (*Triticum aestivum L.*) is one of the major cereal crops with a unique protein, which is consumed by humans and is grown around the world in different environments **(Abedi *et al.*, 2010**). Wheat is foremost among cereals as a main source of

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carbohydrates and protein for both human beings and animals; contains starch (60-90%), protein (11-16.5%), fat (1.5-2%), inorganic ions(1.2-2%) and vitamins (B complex and vitamin E) **(Rueda-Ayala *et al*., 2011)**.

There are many reasons of low productivity of wheat out of which imbalance and excess fertilizer application is major one and changes in physico-chemical composition of the soil, a depletion and diminution in bioavailability of soil nutrients, a scarcity of good groundwater, buildup of pests and attack of various diseases of wheat greatly affected its yield and quality (**Timsina and Connor, 2001)**. Injudicious application of chemical fertilizers not only harms the biological power of soil but also decreases the soil fertility and crop productivity **(Chand 2008, Parewa *et al*. 2014)**. Thus, integrated nutrient management advocates balanced and conjoint use of inorganic fertilizer, organic manure, and bio-inoculants in order to maintenance or adjustment of soil fertility and plant nutrient supply to an optimum level for sustaining desired crop productivity (**Rakshit *et al*. 2008, Parewa *et al*. 2014**).

Nitrogen (N) is major factor for yield of wheat. The efficiency of wheat cultivars to N use has become increasingly important to allow reduction in N fertilizer use without decreasing yield.Wheat is an important cereal crop and requires a good supply of nutrients especially nitrogen for its growth **(Mandal *et al*., 1992)** and yield (**Krylov and Pavlov, 1989**). Nitrogen rate, type of nitrogen, and timing of its application are important factors to increase wheat yield **(Garrido-Lestache *et al*. 2005).** Some studies showed that N fertilization increases the total quantity of flour proteins, resulting in an increase in both gliadins and glutenin (**Dupont and Altenbach, 2003).**

Phosphorus is essential for enhancing seed maturity and seed development (**Ziadi *et al.* 2008**). Phosphorus plays a significant role in several vital functions such as photosynthesis, transformation of sugar to starch, protein information, nucleic acid production, nitrogen fixation and formation of oil. It is also, the part of all biochemical cycles in plants (**Mehrvarz and Chaichi, 2008**).

Potassium (K^+) is of unusual significance because of its live role in biochemical functions of the plant like activating various enzymes, improvement of protein, carbohydrates and fat concentration, developing tolerance against drought and resistance to frost, lodging, pests and disease attack. Therefore, potassium known as "quality element" and it was considered as a key factor in crop production (**Moussa, 2000**).

Zinc is also reported as an important micronutrient for wheat production because it is required in a large number of enzymes and plays an essential role in DNA transcription. . It is reported that high amount of zinc is contained in pollen and mostly zinc is inverted to seed only during seed formation and an application of zinc improves grain formation **(Choudhary *et al*., 2007).**

Generally, crops needs less sulphur like cereals, still start suffering more and more from sulphur deficiency even there are some crops which need more sulphur as well **(McGrath *et al*, 1996).** The baking properties of wheat and the biological value of proteins can also be improved by increasing sulphur fertilization which has reported many times **(Jarvan *et al*., 2006).**

Judicious use of FYM with chemical fertilizers improves soil physical, chemical and biological properties and improves the crop productivity **(Sharma *et al*., 2007).** Application of organic manures may also improve availability of native nutrients in soil as well as the efficiency of applied fertilizers **(Sawrup,2010).**

The need of the hour is to evolve an integrated plant nutrient supply system, comprising balanced use of chemical fertilizer, organic manures and bio-fertilizers. An improvement in crop performance might be attributed to the N_2 -fixing and phosphate solubilising capacity of *Azotobacter* as well as the ability of these microorganisms to produce growth promoting substances (**Salantur *et al*., 2006**). *Azotobacter* and graded doses of nitrogen increase phosphorus and potassium uptake by plants significantly **(Agrawal *et al*., 2004).** Wheat poses problem for the establishment of*Azotobacter* in its rhizosphere. The inoculation of crop plants with bacterial preparation is recommended because a selective and compatible strain is supposed to accelerate plant growth **(Apte and Shende 1981**). Phosphate solubilizing bacteria (PSB) as bio-fertilizers have been found effective in solubilizing the fixed soil P and applied phosphates resulting in higher crop yields (**Panhwar *et al*., 2020**).

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Resources and Methods

Experimental Site

The experiment was conducted during *rabi* season of 2020-21 and 2021-22 at student's Instructional farm, C.S.A. University of Agriculture and Technology, Kanpur Nagar (U.P.). The field was well leveled and irrigated by tube well. The farm is situated at main campus of the university, in the west northern part of Kanpur city under sub-tropical zone in V^{th} agroclimatic zone (central plain zone).

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EdaphicCondition

The soil was moist, well drained with uniform plane topography. The soil of the experimental field was alluvial in origin, sandy loam in texture and slightly alkaline in reaction having pH 8.14 and 8.13 (1:2.5 soil: water suspension method given by **Jackson, 1973**), electrical conductivity 0.45 and 0.44 dSm^{-1} (1:2.5 soil: water suspension method given by **Jackson, 1973**), Organic carbon percentage in soil is 0.42 and 0.43 per cent (Walkley and Black's rapid titration method given by **Walkley and Black, 1934**), with available nitrogen 193.0 and 195.0 kg ha^{-1} (Alkaline permanganate method given by **Subbiah and Asija, 1956**), available phosphorus as sodium bicarbonate-extractable P was 12.84 and 12.86 kg ha^{-1} (Olsen's calorimetrically method**, Olsen *et al.*, 1954**) available potassium was 146.76 and 148.52 kg ha^{-1} (Flame photometer method given by **Hanwey and Heidel, 1952**), available sulphur was8.5 and 8.6 kg ha^{-1}**(**Turbidimetric method given **by Chensin and Yien, 1951) and** available zinc was0.53 and 0.54 ppm**(**DTPA extraction method given by (**Lindsay and Norvell, 1978).**

Detail of treatments and design

The 10 treatments combination of nutrient management practices of inorganic fertilizer (Urea, DAP and MOP), Organic manure (FYM) and Biofertilizer (*Azotobacter* and PSB). Experiment was laid out in randomized block design with three replications.

Table -1:~~detail~~ Detailsof the treatment combinations~~:~~

S.No.	Symbols	Treatment combinations
1.	**T_1**	CONTROL
2.	**T_2**	50%NPK OF R.D.F.
3.	**T_3**	75%NPK OF R.D.F.
4.	**T_4**	100% NPK OF R.D.F.
5.	**T_5**	125% NPK OF R.D.F.
6.	**T_6**	100%NPK+FYM
7.	**T_7**	100%NPK+FYM+S_{30}

8.	**T_8**	100%NPK+FYM+S_{30}+Zn_5
9.	**T_9**	100%NPK+FYM+S_{30}+Zn_5+*Azotobacter*
10.	**T_{10}**	100%NPK+FYM+S_{30}+Zn_5+*Azotobacter*+ PSB

Crop Husbandry

A pre-sowing irrigation (Paleva) was done in the experimental field with an object to get optimum moisture conditions for attaining good germination. At proper tilth, one ploughing with tractor drawn mould bold plough was done followed by two ploughings by cultivator. HalfdoseofNitrogentogetherwithfulldoseofPhosphorus,Potashwereappliedas basal at the time of sowing in the form of Urea, DAP and MOP respectively.Remaininghalfdoseofnitrogenwastopdressedintotwosplitdosesat30and 55daysaftersowing(DAS). The sowing of seeds of wheat cv. HD-2967 was done by linesowing by hand at 2-3 cm depth of soil and with line to line spacing of 22.5 cm to maintainuniform plant population. Application of FYM and Soil treatment with *Azotobacter* and PSB was done.

Harvesting and threshing: the crop was harvested at maturity and was allowed to dry in sun. Separate bundles were made for each plot and weighted. The after drying harvest was threshed manually.

Data Collection

Grain yield

After threshing the grain yield from each plot was separately weighed and recorded after converting into quintals per hectare.

Straw yield

After subtracting the grain yield per plot from the total biological yield. After converting the yields into quintals per hectare, yields were recorded.

Statistical analysis: The growth parameters and yields were recorded and analyzed as per Gomez and Gomez (1984) the tested at 5% level of significance to interpret the significant differences.

Result and Discussion

Growth Parameters

A critical perusal of the data given in Table-2 clearly shows that among the growth parameters of wheat such as plant height (cm) at maturity, maximum number of effective tiller ^{1} and spike length significantly increase due to the application of nitrogen, Zinc, Sulphur, FYM,*Azotobacter* and PSB. Growth parameters also increased with lapse of time. Plant height at maturity varied from 91.19-109.68 cm maximum number of effective tillersvaried from 284.61-354.10and spike length varied from 9.52-13.67 cm on pooled basis. Maximum plant height (110.12cm) at maturity, maximum number of effective tillers(355.72) and maximum spike length (13.79 cm)was associated with the treatment T_{10} [100%NPK + FYM + S_{30}+ Zn_5 +*Azotobacter* + PSB]during the second year (2021-22) of experimentation. Minimum plant height (91.12 cm) at maturity, minimum number of effective tiller ^{1}(283.58) and spike length (9.40 cm) was associated with the treatment T_1 [control] during the first year (2020-21) of experimentation. The growth parameters of wheat might be increased due to Nitrogen (N) is major factor for yield of wheat. The efficiency of wheat cultivars to N use has become increasingly important to allow reduction in N fertilizer use without decreasing yieldIt is reported that high amount of zinc is contained in pollen and mostly zinc is inverted to seed only during seed formation and an application of zinc improves grain formation**.**The baking properties of wheat and the biological value of proteins can also be improved by increasing sulphur fertilization which has reported many timesapplication of organic manures may also improve availability of native nutrients in soil as well as the efficiency of applied fertilizers.. Organic materials, such FYM and their continuous use have a strong influence on soil productivity and N dynamics in the soil–plant system. *Azotobacter* and graded doses of nitrogen increase phosphorus and potassium uptake by plants significantly**.** Wheat poses problem for the establishment of*Azotobacter* in its rhizosphere. Phosphate solubilizing bacteria (PSB) as bio-fertilizers have been found effective in solubilizing the fixed soil P and applied phosphates resulting in higher crop yields**.** The consequences of the current investigation are additionally in concurrence with the investigation of**Agrawal *et al*., (2004),Jarvan *et al*., (2006), Choudhary *et al*., (2007), Sawrup,(2010), Panhwar *et al*., (2020) and Choudhary*et al.* (2022)**

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Table-2: Effect of different treatment combination on growth parameters of wheat

Treatments	Plant Height (cm) at Maturity			Number of effective tillers			Spike length (cm)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled

T_1	91.12	91.25	91.19	283.58	285.63	284.61	9.40	9.65	9.52
T_2	93.46	93.57	93.52	288.65	291.47	290.06	10.25	10.56	10.41
T_3	95.52	95.64	95.58	292.71	295.56	294.14	10.65	10.92	10.79
T_4	97.87	97.98	97.93	298.62	301.24	299.93	11.12	11.32	11.22
T_5	99.74	99.86	99.80	315.26	318.69	316.98	11.96	12.10	12.03
T_6	98.42	98.55	98.49	305.39	307.42	306.41	11.52	11.98	11.75
T_7	101.45	101.52	101.49	322.48	325.54	324.01	12.13	12.56	12.35
T_8	103.76	103.84	103.80	335.47	337.67	336.57	12.68	12.92	12.80
T_9	106.48	106.62	106.55	343.19	346.96	345.08	13.16	13.62	13.39
T_{10}	109.25	110.12	109.68	352.67	355.72	354.10	13.55	13.79	13.67
SE(m) ±	1.31	0.73	0.86	3.02	4.82	5.80	0.21	0.21	0.21
C.D. at 5 %	3.93	2.17	2.57	9.04	14.43	17.38	0.64	0.64	0.62

Yield Components

At a glance over the data given in the Table-3 clearly shows that among the yield attributing characters of wheat such asSpikelet ear^{-1}, Grain ear^{-1}and 100 grain weight (gm) significantly increase due to the application of Nitrogen, , Zinc, Sulphur, FYM, *Azotobacter* and PSB. Significantly response on yield components was recorded with T_{10} [100%NPK + FYM + S_{30}+ Zn_5 +*Azotobacter* + PSB]over other treatments. The Spikelet ear^{-1}, Grain ear^{-1}and 100 grain weight (gm) increased to the magnitude of 36.97 to 45.56, 4.36 to 6.6 and 59.4 to 67.65 respectively, on pooled basis. Maximum number of spikelet ear^{-1}(22.93), number of grain ear^{-1} (3.32) and 100 grain weight (33.91gm) was associated with the treatment T_{10} [100%NPK + FYM + S_{30}+ Zn_5 +*Azotobacter* + PSB]during the second year (2021-22) of experimentation. Minimum number ofSpikelet ear^{-1} (18.34), number of grain ear^{-1} (2.17) and 100 grain weight (29.51gm) was associated with the treatment T_1 [Control] during the first year (2020-21) of experimentation. The results of the present investigation are also in agreement with the findings of **Shaharoona *et al.* (2006), Prasad *et al.* (2010), Mahato and Kafle (2013),Yadav *et al.* (2017),Rathwa *et al.* (2018),Maurya *et al.* (2019) and Kumar *et al.* (2022).**

Table-3: Effect of different treatment combinations on yield components of wheat

Treatments	Spikelet ear^{-1}			Grain ear^{-1}			100 Grain Weight (gm)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	18.34	18.63	36.97	2.17	2.19	4.36	29.51	29.89	59.4
T_2	18.62	18.86	37.48	2.38	2.40	4.78	30.12	30.45	60.57
T_3	18.91	19.11	38.02	2.73	2.76	5.49	30.65	30.89	61.54
T_4	19.19	19.63	38.82	2.89	2.92	5.81	31.10	31.35	62.45
T_5	19.56	19.89	39.45	2.95	2.98	5.93	31.64	31.93	63.57
T_6	19.82	20.16	39.98	2.98	3.07	6.05	32.15	32.42	64.57
T_7	20.19	20.56	40.75	3.05	3.09	6.14	32.68	32.80	65.48
T_8	20.52	20.75	41.27	3.14	3.18	6.32	32.00	33.12	65.12
T_9	21.11	21.63	42.74	3.22	3.26	6.48	33.45	33.65	67.1
T_{10}	22.63	22.93	45.56	3.28	3.32	6.6	33.74	33.91	67.65
SE(m) ±	0.21	0.37	0.37	0.39	0.40	0.22	0.46	0.51	0.48
C.D. at 5 %	0.63	1.10	1.11	1.17	1.19	0.67	1.39	1.51	1.44

Productivity Parameters

It is visualized from the data given in Table-4 clearly indicate that among the productivity parameters viz. grain yield (q ha^{-1}) and straw yield (q ha^{-1}) significantly increase due to the application of Nitrogen, , Zinc, Sulphur, FYM, *Azotobacter* and PSB. Grain yield varied from 30.31 to 54.21 q ha^{-1}, straw yield varied from 45.51to 76.86q ha^{-1}. The maximum grain yield (50.94 q ha^{-1}), straw yield (76.86q ha^{-1}) was associated with the treatment T_{10} [100%NPK + FYM + S_{30}+ Zn_5 +*Azotobacter* + PSB] during the second year (2021-22) of experimentation. The minimum grain yield (30.31q ha^{-1}), straw yield (45.51q ha^{-1}) was found under the treatment T_1 [control] during the first year (2020-21) of experimentation during the second year (2021-22) of experimentation. The surge in seed and straw yields under adequate nutrients supply might be attributed to mainly to the collective effect of a greater number of spikelet ear^{-1}, grains ear^{-1} and higher test weight, which was the result of improved translocation of photosynthates from source to sink ultimately yield is increased. The increase in grain yield under adequate nutrients supply mainly due to more yield attributes ultimately resulted more grain yield. Grain and straw yield of

Comment [SC15]: should be in passive form wheat significantly increased due to nitrogen 270 (kg ha^{-1}) and FYM(10t ha^{-1}) over their controls. Inoculation of Azotobacter and PSB further increased grain & straw yield of wheat significantly over without inoculation. It may due to treatment of soil with bio-inoculant which fix atmospheric nitrogen and increased the supply of other nutrients to plants and ultimately increased grain and strawyield of wheat. These results also confirms the findings of **Kumar *et al*. (2017)**, **Yadav *et al.* (2017), Yadav *et al.* (2018),Kumar *et al.* (2022),and Sirohiya*et al.* (2022)**

Table-4: Effect of different treatment combinations on productivity parameters of wheat

Treatments	Grain Yield (q ha^{-1})			Straw Yield (q ha^{-1})		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	30.31	31.15	30.73	45.51	46.45	45.98
T_2	33.23	33.79	33.51	50.21	51.65	50.93
T_3	36.12	36.95	36.15	53.13	54.19	53.66
T_4	40.32	40.51	36.54	55.18	56.91	56.05
T_5	42.15	42.46	40.42	59.23	60.25	59.74
T_6	46.20	46.66	42.31	62.52	63.96	63.24
T_7	47.82	48.21	46.43	65.25	66.56	65.91
T_8	48.33	48.85	48.02	72.52	73.21	72.87
T_9	50.13	50.94	48.59	75.85	76.86	76.36
T_{10}	53.79	54.21	50.54	80.76	81.35	81.06
SE(m) ±	0.57	0.63	0.67	0.61	1.02	1.05
C.D. at 5 %	1.71	1.87	2.01	1.83	3.05	3.15

Conclusion

The current study demonstrate the benefit of nitrogen,Zinc,Sulphur, FYM, *Azotobacter* and PSBalone with recommended N, K for achieving higher growth parameters and productivity by wheat crop. Application of nitrogen, Zinc, Sulphur, FYM, *Azotobacter* and PSB increased yield attributes and yield of wheat crop. Finally it can be concluded that the treatment T_{10}

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[100%NPK+FYM+S_{30}+Zn_5+*Azotobacter*+ PSB] is a best option for improving productivity of wheat crop.

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